Accident Investigation and Analysis - a roadmap for organisational learning -

Celeste Jacinto
Industrial Engineering, Universidade Nova de Lisboa

UNIVERSIDAD DE MÁLAGA

Thematic Seminar presented at
Universitad de Málaga
28 November 2016

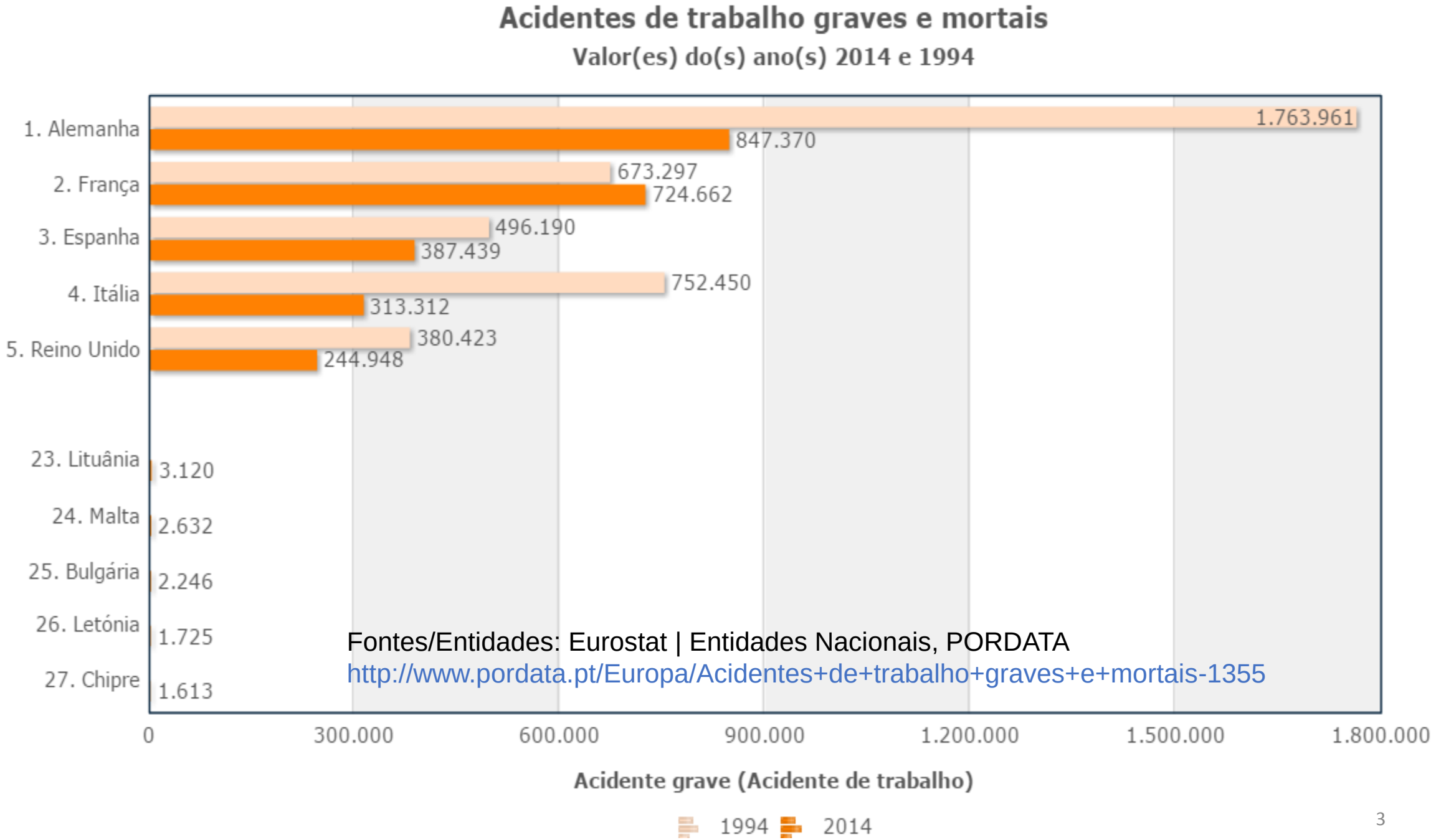
Why? Why bother? Why me? Why you?

-Working conditions have improved enormously

-But risk acceptability has also changed greatly

-Accident numbers are decreasing, but still high

-You are the generation that shapes the future



Fontes/Entidades: Eurostat | Entidades Nacionais, PORDATA
http://www.pordata.pt/Europa/Acidentes+de+trabalho+graves+e+mortais-1355

AGENDA

1. Basic definitions & terminology
2. Models of accident causation
3. Methods of accident investigation and analysis
4. Fundamentals of RIAAT process for dealing with accidents at work

OBJECTIVE

To address ways of *investigating and analysing* accidents that also promote organisational learning and, therefore, are aligned with modern safety management thinking.

Reference literature on the topic

- **Reason, James (1997)**, “Managing the risks of organisational accidents”, Ashgate Publishing Ltd, Aldershot Hants
- **Kjellén, Urban (2000)**, “Prevention of accidents through experience feedback”, Taylor & Francis, London.
- **HSE – CRR (2001)**, “Root causes analysis – literature review”, By: W.S. Atkins, Contract Research Report 325/2001 for the Health and Safety Executive, HSE Books, UK
- **NRI – The Noordwijk Risk Initiative Foundation (2002),** “3CA – Control Change Cause Analysis Manual”, By: John Kingston, NRI-3. The Netherlands. Available at: www.nri.eu.com
- **HSE - Health and Safety Executive (2004),** “Investigating accidents and incidents”, *Guidance* HSG245, HSE Books, UK. ISBN: 0-7176-2827-2. (PO Box 1999, Sudbury, Suffolk CO10 2WA, UK). Available at: http://www.hsebooks.com/Books/
- **Jacinto, C.; Guedes Soares, C.; Fialho, T. and Silva, A.S. (2011).** The Recording, Investigation and Analysis of Accidents at Work (RIAAT) process. Policy and Practice in Health and Safety Vol.9(1), pp. 57-77. IOSH Publications, UK, ISSN: 1477-3996.
- **Jacinto, C.; Guedes Soares, C.; Fialho, T. and Silva, A.S. (2010).** Users Manual. RIAAT - Recording, Investigation and Analysis of Accidents at Work (2010). http://www.mar.ist.utl.pt/captar/en/riaat.aspx
- **Eurostat (2013).** European Statistics on Accidents at Work (ESAW) – Methodology. Luxembourg. European Commission, DG Employment & Social Affairs, 2013 (metodologia EEAT).
- **AENOR**: Norma UNE-EN 62740:2015. Root Cause Analysis (Manual)

1. Basics & terminology (1)

Accident

- ✓ Randomness / unplanned / sudden event
- ✓ Energy transfer (some kind of “contact”)
- ✓ Specific consequence: injury to people, damage to property or the environment

Near-miss or dangerous occurrence

Undesired occurrence that *may have had* critical effects, *i.e.*, the damaging consequences are not actually present – it only has the potential to cause them.

1. Basics & terminology (2)

Investigation – means a search for factual accident data; implies a systematic search of the relevant facts; it is essentially about fact-finding and the identification of observable elements (data)

Analysis – holds the need to interpret data and to establish causal links

>> search for logical explanations rather than facts and events

>> a certain amount of information might be inferred

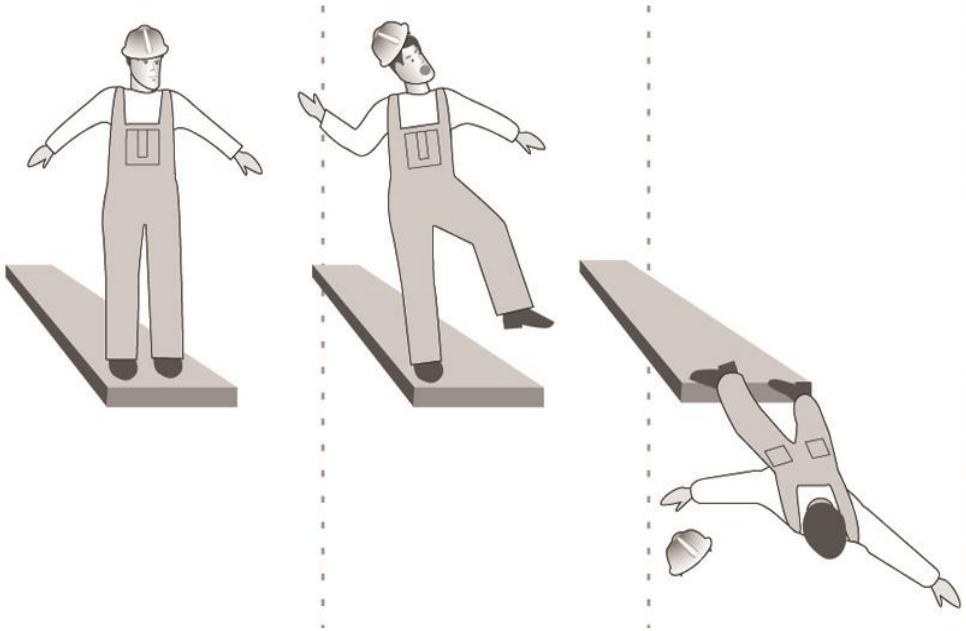
Investigation and Analysis can be seen as iterative processes, which are complementary to each other

1. Basics & terminology (3)

Learning

"the processes related to establishing new knowledge aiming to implement changes to, or gaining deeper comprehension of, and/or confirming the basis for current practices" (Njå & Braut, 2010)

learning implies change



2. Models of accident causation

Accident Prevention

relationship between models and methods

Models (theories)

To explain the accident mechanism (causation theories)

Methods (tools)

To help a user performing a specific task

Risk Assessment (pro-active monitoring)

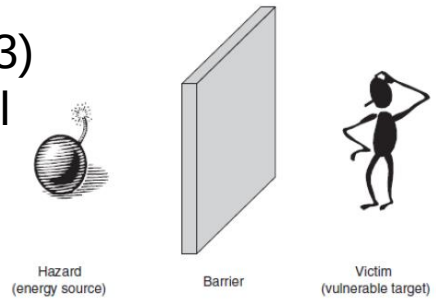
Accident Investigation & Analysis (reactive monitoring)

Review of Models – some milestones

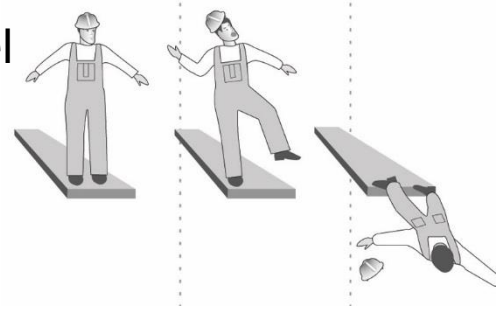
Sequential – chain of events

Heinrich (1931) – Domino theory
Bird (1974) – Loss Control
(modified domino)

Haddon (1973)
Energy model



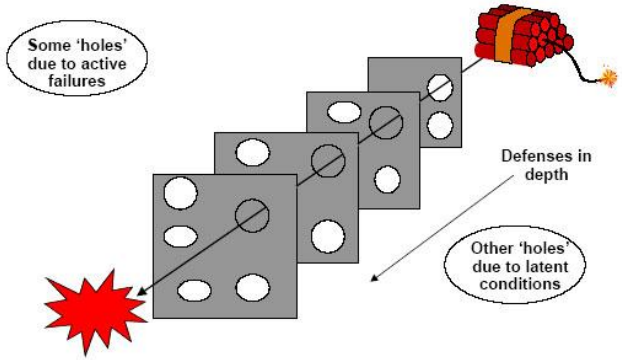
Kjellén (1984)
Deviation model



Epidemiological

Turner (1978) –
Incubation/Trigger
Event Theory

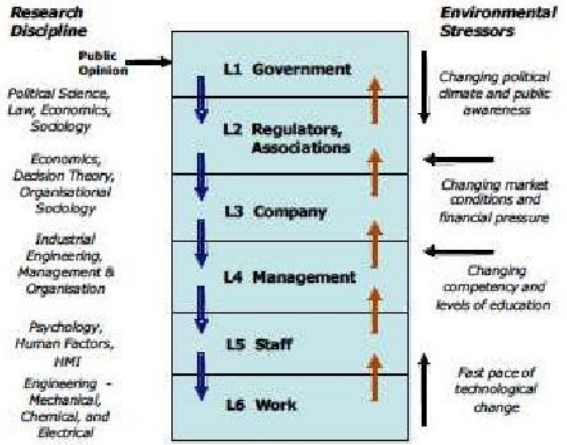
Reason (1990, 1997)
"Swiss Cheese" Model
Organisational Accidents



Systems approach

Rasmussen (1997)
Svedung & Rasmussen (2002)

HIERARCHICAL MODEL OF SOCIO-TECHNICAL SYSTEMS

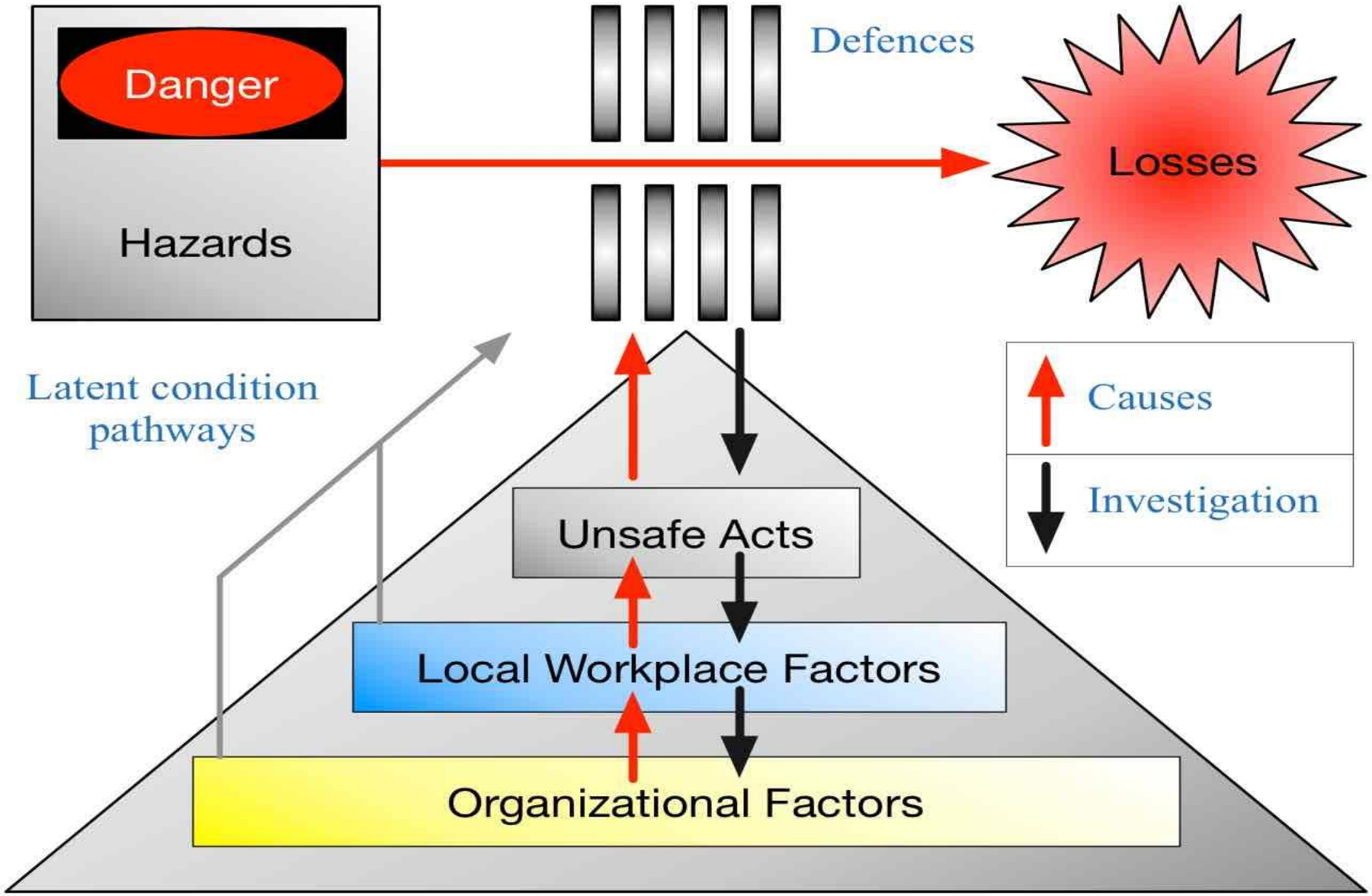


(Rasmussen, 1997)

Multi – causality (current approaches)

Not a single cause (or a single sequence), but rather the interaction of multiple causes

Reason model (1997) – Organisational Accidents



Reason model (1997) – Organisational Accidents Key concepts

We find multiple failures within an organisation. When combined with each other, these failures can result in an accident

Active Failures – their effects are felt immediately. They play an "active" roll on the accident occurrence. Usually are easy to identify and represent the "immediate causes"

e.g.: technical failure from equipment or materials, or human error from worker,

Reason model (1997) – Organisational Accidents Key concepts

Latent failures (or latent conditions) – their pernicious consequences are not immediately visible, and are not immediately associated with the accident

These are normally weaknesses in the organisation which facilitate the occurrence of active failures. They can be "dormant" in the system for long periods without being detected. Only become evident in the aftermath of an accident, when combined with other factors

e.g.: insufficient supervision, poor maintenance, ill designed machines or tools, bad procedures, poor management, etc.

Reason model (1997) – Organisational Accidents Key concepts

In summary: the model considers 3 levels of concern:

1- Organisation & management: the weak points within the organisation – the latent conditions

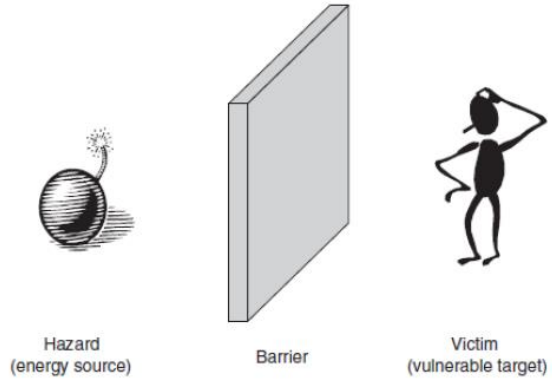
2- Working environment: it will influence or promote unsafe behaviours

3- People: unsafe acts, or behaviours from workers

These factors, combined with technical failures and poor barriers (defences) can result in an accident or near-miss

Reason model (1997)

Barriers / Defences



Physical

Fences, machine guards, electrical insulation, gas detectors, ventilation systems, PPE, etc.

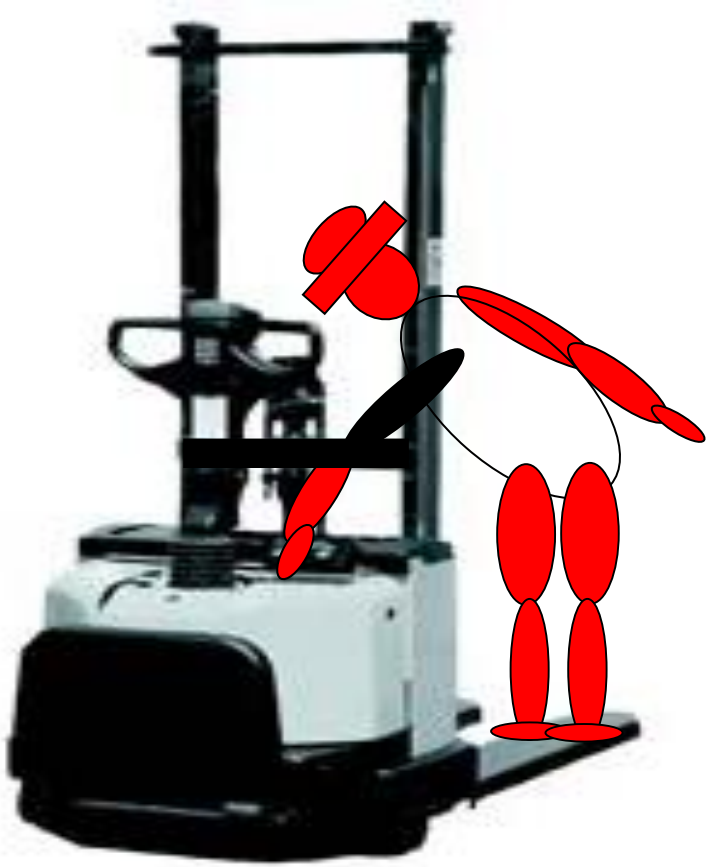
Most commonly >> “active” failures

Administrative

Norms, warnings, rules, safety procedures, work permits, etc.

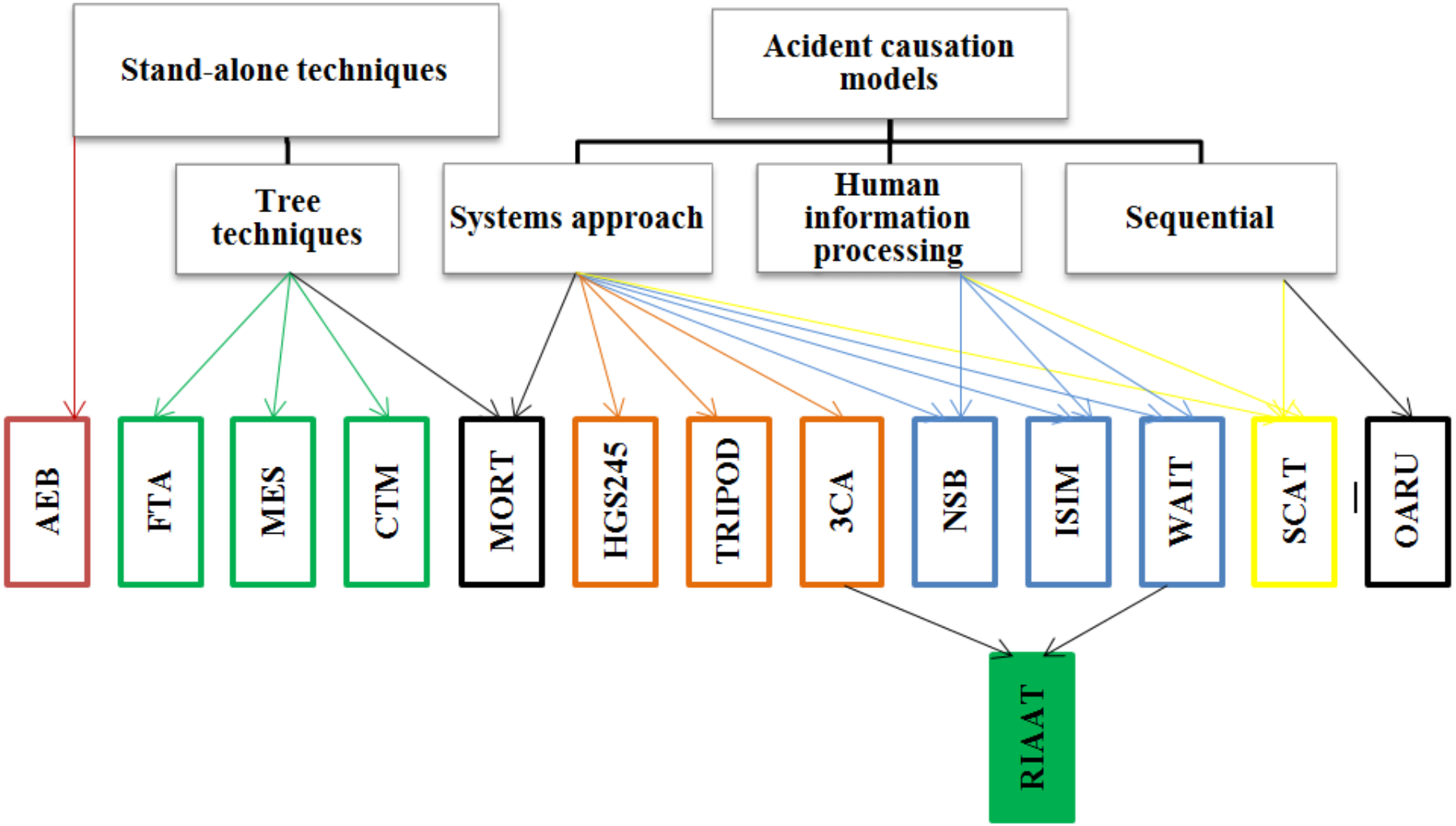
Most commonly >> “latent” conditions

Failures in defences can contribute in various ways: absence, existing but not known by workers, bad use, insufficient, bad design (difficult to use or uncomfortable)



3. Methods of accident investigation

Relationship between methods and underlying models



Source: adapted from Katsakiori et al. / *Safety Science* 47 (2009), pp 1007–1015

Investigation and Analysis of Accidents – accidents at work

Investigating Accidents and Incidents – Users Manual – Guidance HSG245 (2004)
http://www.hsebooks.com/Books/

3CA (*Control Change Cause Analysis*) - Users Manual (2002 and 2009) published by NRI. http://ww.nri.eu.com

WAIT - Work Accidents Investigation Technique. Verlag Dashofer (2003, 2011 4ª Ed.)
adopted by the Portuguese Labour Inspectorate for official enquiries on serious accidents
English version: http://xenofonte.demi.fct.unl.pt/wait_method

RIAAT - Recording, Investigation and Analysis of Accidents at Work (2010)
Proj. CAPTAR: http://www.mar.ist.utl.pt/captar/ **(adopted by the Portuguese Labour Inspectorate)**

RCA - Root Cause Analysis (Análisis de Causa Raíz). 2015.
AENOR: Norma UNE-EN 62740:2015

4. "*RIAAT in a nutshell*"

- ✓ **just a brief outline of the RIAAT Process**
- ✓ **functions: Recording, Investigation and Analysis of Accidents**
- ✓ **it is a Process (or procedure) to deal with accidents at work**
- ✓ **accommodates the <u>whole cycle of accident information</u>**

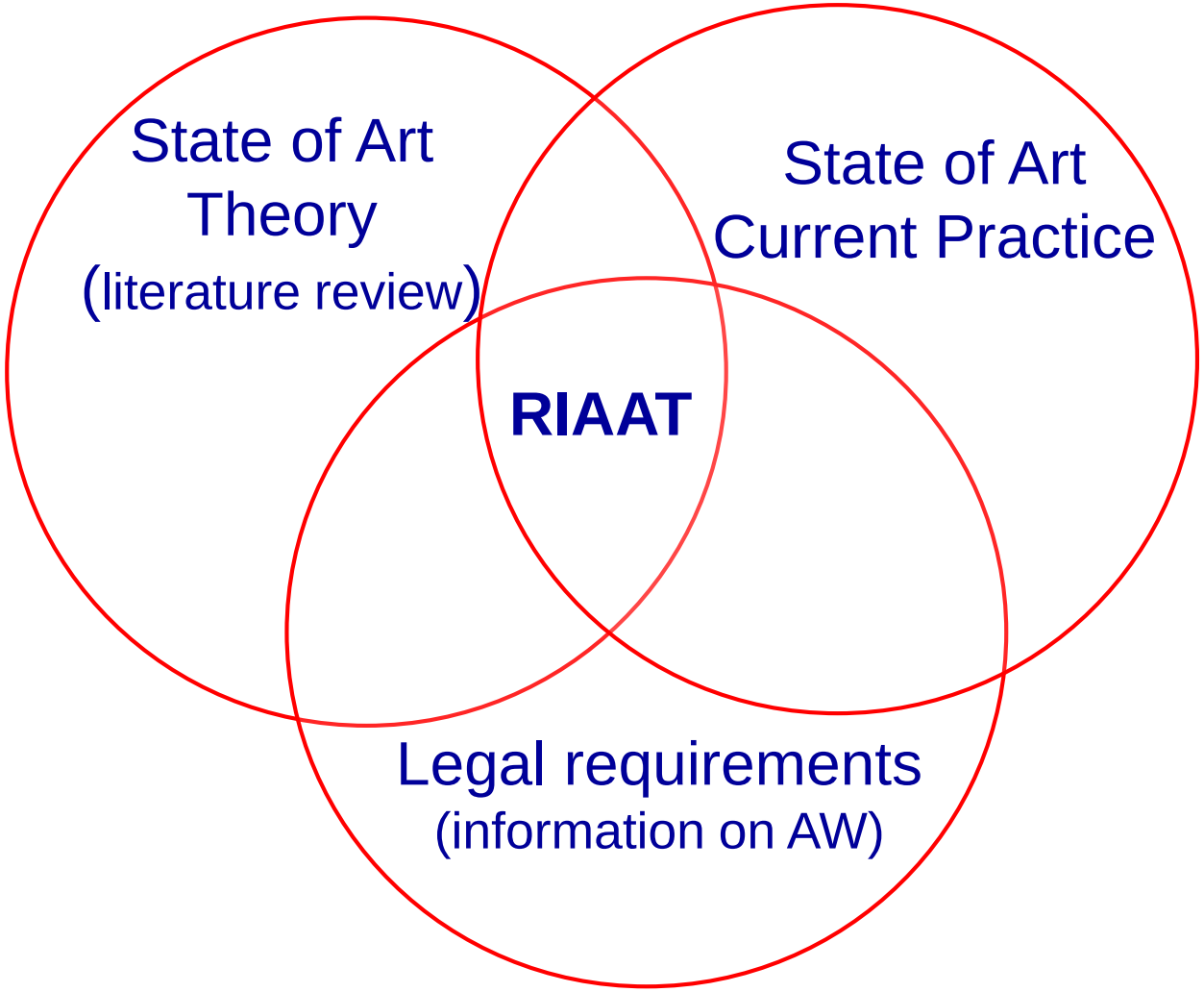
Motivation for RIAAT – move from “records” to (safety) learning and improvement

Basic Postulates

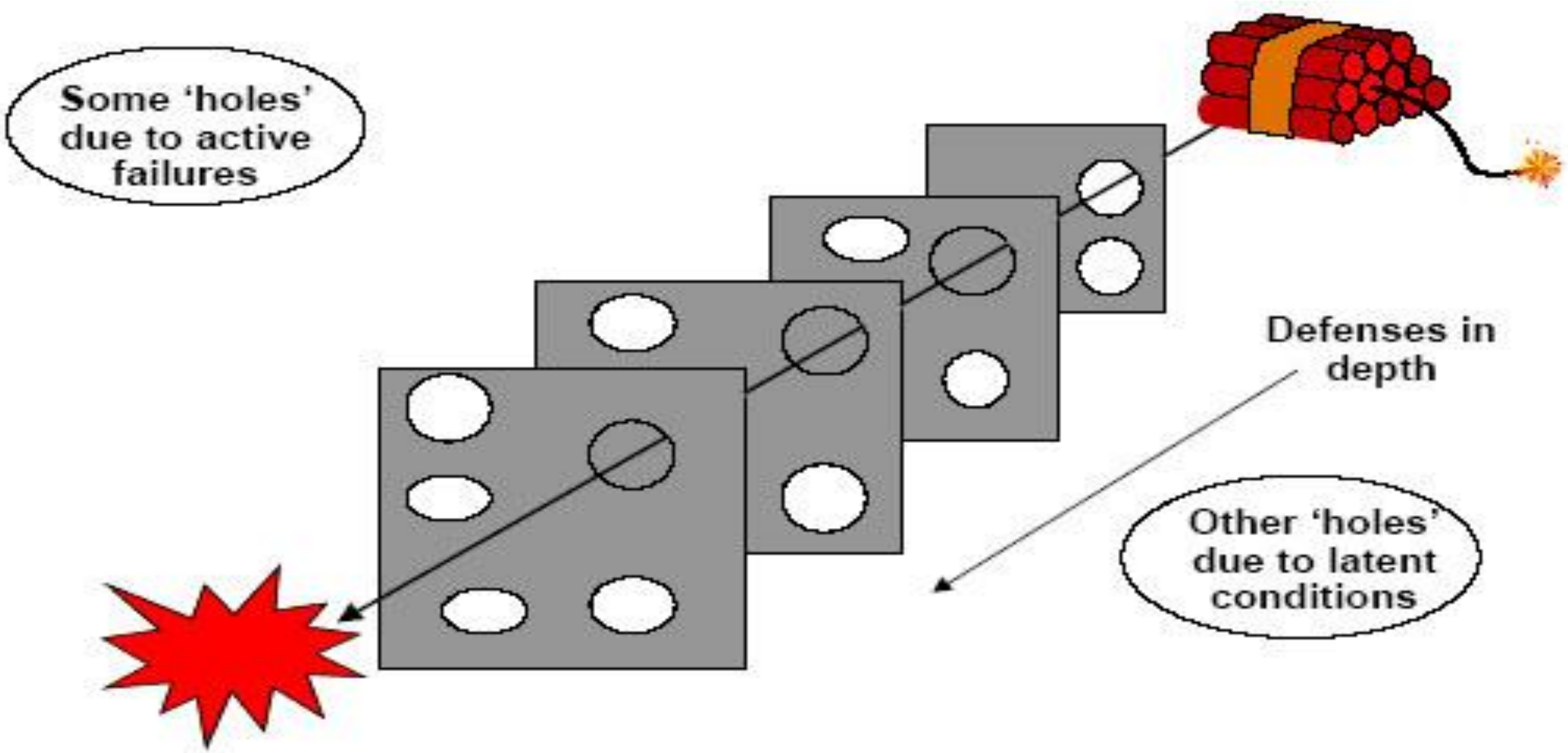
- To prevent, one needs to know (i.e., understand the phenomena; have reliable information)
- Knowing assumes learning
- Learning also implies the ability of new knowledge to convey *changes* and *improvements* where they are actually needed
- The effect is amplified when learning is shared across the organisation (organisational learning)

Background / Development philosophy

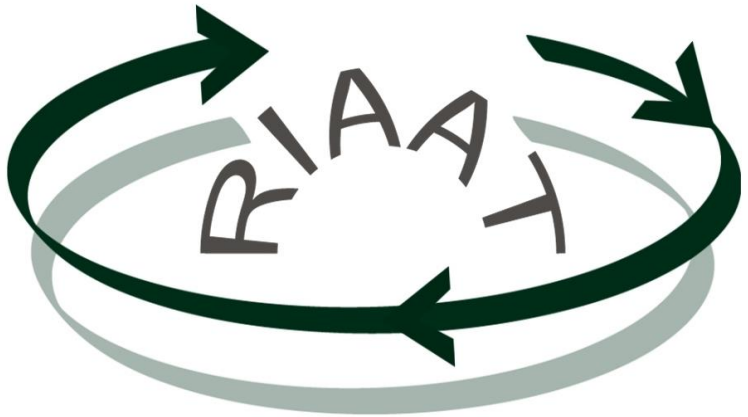
RIAAT resulted from the intersection of three main areas of knowledge



Background ... Reason's theory



Summary of RIAAT



Management <u>Process</u>, materialised by two instruments:

- a FORM (standard form). The methodology of analysis is embedded in the form (6p)

-A User's Manual (15p); step-by-step guidance

FORM: simple, practical and structured

Recording, Investigation & Analysis of Accidents

Accident at Work

Dangerous Occurrence

Process No: ___ / Year

Instructions: see Revision 1.1 of user's manual

May 2010

Case Number:	Record Date:
000	yyyy/mm/dd

☐ Accidental Work, If (Yes) ☐ Fatal ☐ Non Fatal

☐ Dangerous Occurrence

Notified to the Insurance company ☐ Yes ☐ NO If (Yes), Who notified: xxxxxxxxxxxx

PART I: RECORDING

Note: all fields marked with (E) are European harmonised variables (Eurostat, ESAW system).

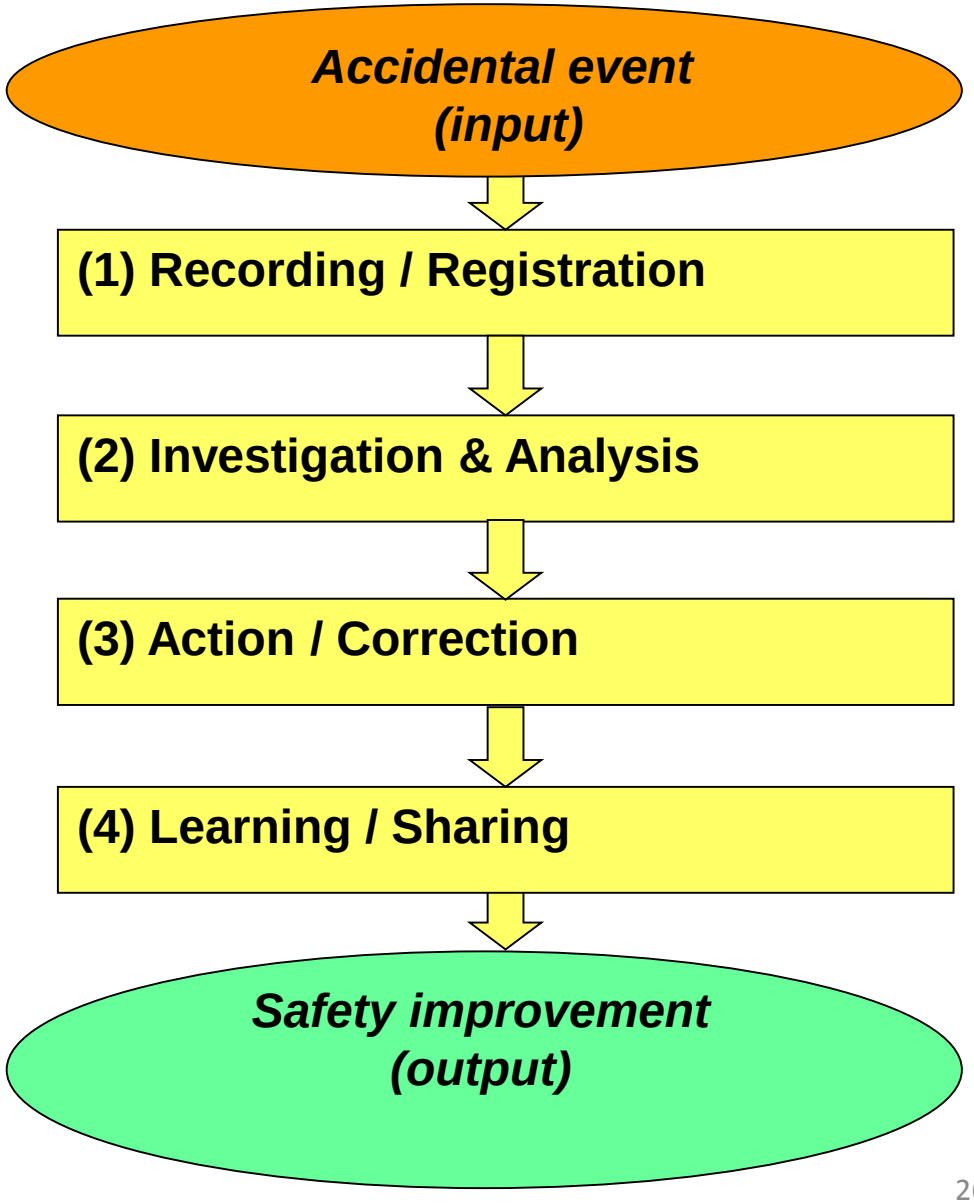
	Section 1	Victim Information	
1.1	Full Name	xxxxxxxxxx	
1.2	Address Postal code	xxxxxxxxxx	Contact (Phone/Mobile): xxxxxxxxxx
1.3	Age ■	xx	
1.4	Sex ■	☐ Men (1) ☐ Women (2)	
1.5	Nationality ■	xxxxxxxxxx [0] (2-description and code in accordance with ESAW)	
1.6	Occupation ■	xxxxxxxxxx [0][0] (2-description and code in accordance with ESAW)	
1.7	Department	xxxxxxxxxx	
1.8	Date of Admittance (company)	xxxxxxxxxx (yyyy/mm/dd)	
1.9	Employment Status ■	xxxxxxxxxx [0][0][0] (2-description and code in accordance with ESAW)	

Section 2		Accident Information
2.1	Time ■ /Date of Accident ■	The accident occurred at: xxxx, on xxxx (hh:mm - 24 hour clock) (yyyy/mm/dd)
2.2	Working Environment ■	(Identify the workplace or working area where the victim was present at time of the accident - storage, construction site, quarry or mine, office, farming or fitness zone, etc.) xxxxxxxxxx [0][0][0] (2-description and code in accordance with ESAW)
2.3	Full Accident Description. How did the accident happen?	(Give the known circumstances of the accident, including what the injured person was doing just before the accident and what happen, i.e., the full sequence of events, and how the person was injured) xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx Additional Information (?) xxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxxx

A “process” in 4 parts

The term **process** implies:

- ✓ a set of related **activities**
- ✓ **transformation** (inputs & outputs are different)
- ✓ obtaining **added value**



Part 1 – Recording

2 pages; ~ notification to authorities

PART I: RECORDING

Note: all fields marked with (E) are European harmonised variables (ESAW system, Eurostat, 2001).

Section 1	Victim Information (intentionally kept anonymous in this example)

This Section 1 includes: (1.1) Full Name of victim, (1.2) Address details, (1.3) Age (E), (1.4) Sex (E), (1.5) Nationality (E), (1.6) Occupation (E), (1.7) Department, (1.8) Date of admittance in the company, and (1.9) Employment Status (E)

Section 2		Accident Information (or Dangerous occurrence)	
2.1	Time (E) /Date of Accident (E)	The accident occurred at 12:20 h (hh:mm - 24 hour clock) on 2009/ 11/ 20 (yyyy/ mm/ dd)	
2.2	Working Environment (E)	(Identify the workplace or working area where the victim was present at time of the accident – storage, construction site, quarry or mine, office, shop, or street, slope, etc.) Garden, park | 0 | 3 | 6 (Description and code in accordance with ESAW)	
2.3	Full Accident Description. How did the accident happen?	(Give the known circumstances of the accident, including what the injured person was doing just before the accident and what happen, i.e., the full sequence of events, and how the person was injured). The worker (gardener) was climbing a tree for pruning. He was equipped with the necessary personal protection equipment (PPE) to climb (harness, carabiners, safety rope, climbing rope and climbing ascender). After the rope was thrown, the anchorage point (a branch of the pine tree) was tested for strength; only then the worker started to climb. When reaching approximately 10 meters of height, suddenly he falls down to the ground (free fall). This fall resulted in an open fracture to his left leg. The "INEM" (National Emergency Services) transported him to St John Hospital, where he was submitted to surgery to his left lower limb. After the event, the witnesses at the site noticed an open spring of the climbing ascender on the floor. Additional information (gathered after the event) 1. the open spring (of climbing ascender) on the ground was a direct consequence of the fall, rather than its cause; 2. the main failure was the absence of the Prusik knot (it would have locked the fall). Attachments: ☐ Photo(s) ☐ Sketch(s) ☒ Other(s) - Hospital report (emergency room); statements of witnesses	
2.4	Active Failures	(In this field, all the "active failures" directly involved in the accident should be identified) - see Section 3 of the user's manual. Later on you will investigate the factors that have contributed to them. 1º - The injured person did not make the Prusik knot on the climbing rope (before climbing) 2º - The injured person suddenly falls from height - 10 meters (last / distant event)	
2.5	Deviation (E) and Material Agent (E)	(Identify the deviation from normal activities or conditions, which led to the accident - the event that corresponds to the last active failure and has caused the accident. The deviation could be, for instance: fire, leak, fall, slipping, wrong body movement, loss of control, etc.) Fall of person - from top of the pine tree | 5 | 1 (Description and code in accordance with ESAW)	(The principal Material Agent associated or linked with the deviant event) Tree (pine tree) | 1 | 8 | 0 | 1 (Name and code in accordance with ESAW)
2.6	Contact - mode of injury (E) and Material Agent (E)	(Describe how the victim was hurt "physical or mental trauma" by the material agent that caused the injury. The mode of injury could be, for instance: the contact with electrical voltage, hazardous substances, crash from fall, struck by object in motion, etc.) Vertical motion of the injured person - fall, against | 3 | 1 (Description and code in accordance with ESAW)	(The principal Material Agent associated or linked with the injuring contact) Surfaces - at ground level | 0 | 1 | 0 | 2 (Name and code in accordance with ESAW)
2.7	Witnesses	☒ Yes ☐ No If (Yes), number of witnesses: 3	(Fill in the Full name(s) and contact(s) of Witnesses) Full Names: kept anonymous Contacts: kept anonymous

- plain record of the accident or dangerous occurrence; it states the basic facts and circumstances
- The form is self-explanatory; and all one needs to do is filling in the applicable fields (Sections 1-3).
- This first part of the process is aligned with the ESAW / EEAT methodology (Eurostat)

Part 1 (optional in step 2.4) – Recording of Active Failures

Active Failures are many and diverse

Can be classified into 5 main categories (WAIT, 2011)

HUM – Human (behaviour, actions)

E&B – Equipments & Buildings (equipments, tools, structures, buildings, etc.)

HAZ – Hazards (hazardous substances, energies, materials and objects, etc.)

LOR – Living Organisms (animals, plants, micro organisms, etc.)

NAT – Natural Phenomena (when they are a direct cause in the accident)

Nature of active failures

(1) HUM – actions and behaviours

Bad movements; inopportune

False moves

Slips, trips, falls (STF)

Excessive force; Cargo handling

Driving (dangerous) of vehicles or machines

Using tools (misuse, unknowing)

Loss control of a tool, or object,

or machine

(2) E&B – Equipment & Buildings (structures).

Structural collapse: scaffolding, platforms

Breaking, bursting: cables, ropes

Vehicles in movement (poor condition)

Equipment and tools (defective)

Batteries, generators, electrical equipment

(3) HAZ – Hazards

Hazardous materials and substances

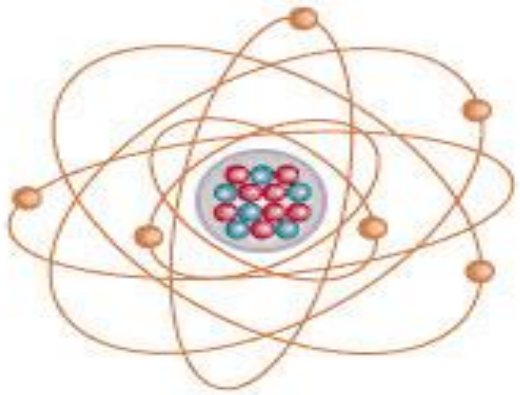
Flammable or explosive substances

Radioactive Materials

Particles, dust, debris, fragment

Sharp objects

Loads suspended or transported



(4) LOR – Living Organisms

Micro organisms: bacteria, viruses, bacilli

Animals: dog bite, mouse, snake

Insects: wasp sting, bee (acute allergic reaction)

Vegetation, trees: fall, tripping, allergic contact

(5) NAT – Natural phenomena

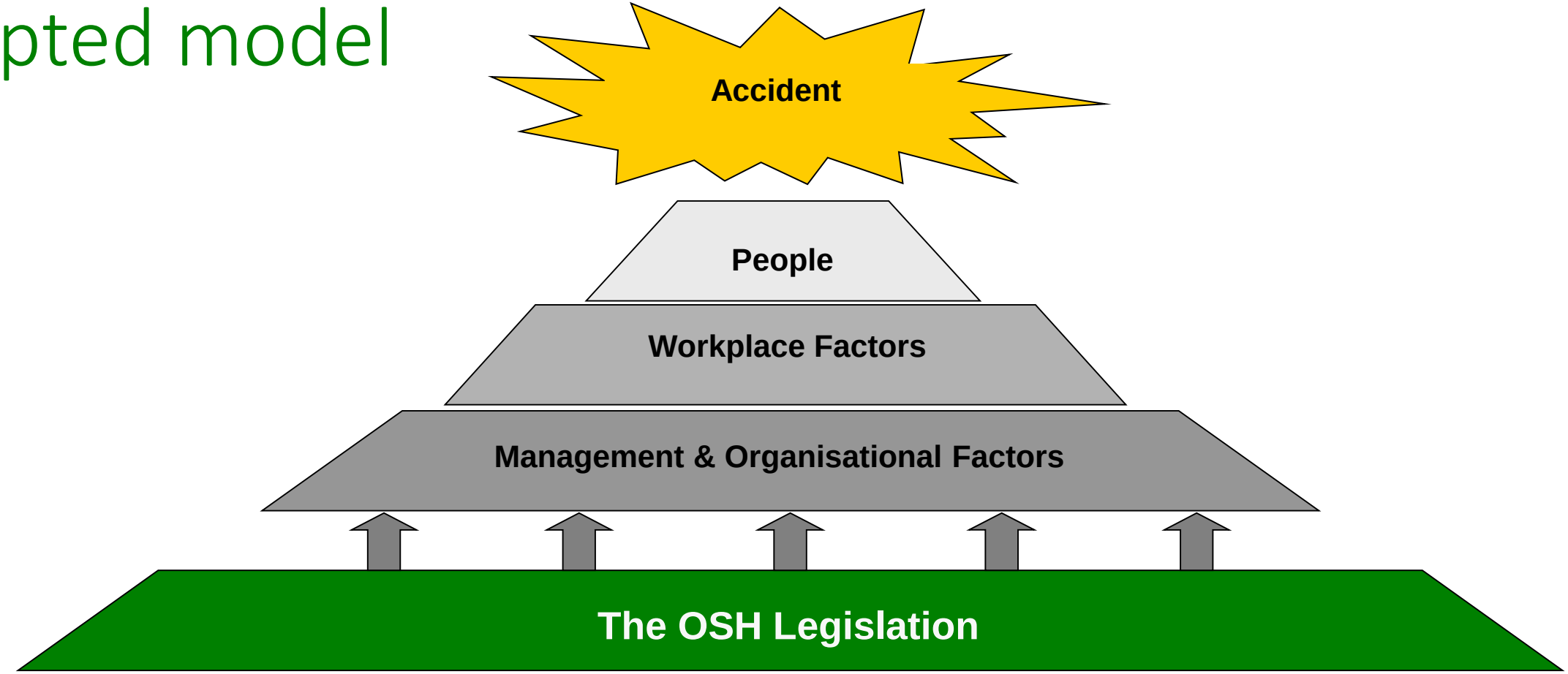
Characteristics of the land: holes, caves, abrupt slopes, trenches, water courses, etc. (fall, landslide)

Soil and slippery surfaces: snow, ice, mud, etc. (paths conditions and / or excavation sites)

Work under adverse climatic conditions: intense sun, rain, hail, strong winds, electric shock, storms, etc.

Part 2 of RIAAT – Investigation & Analysis (causes)

Adapted model

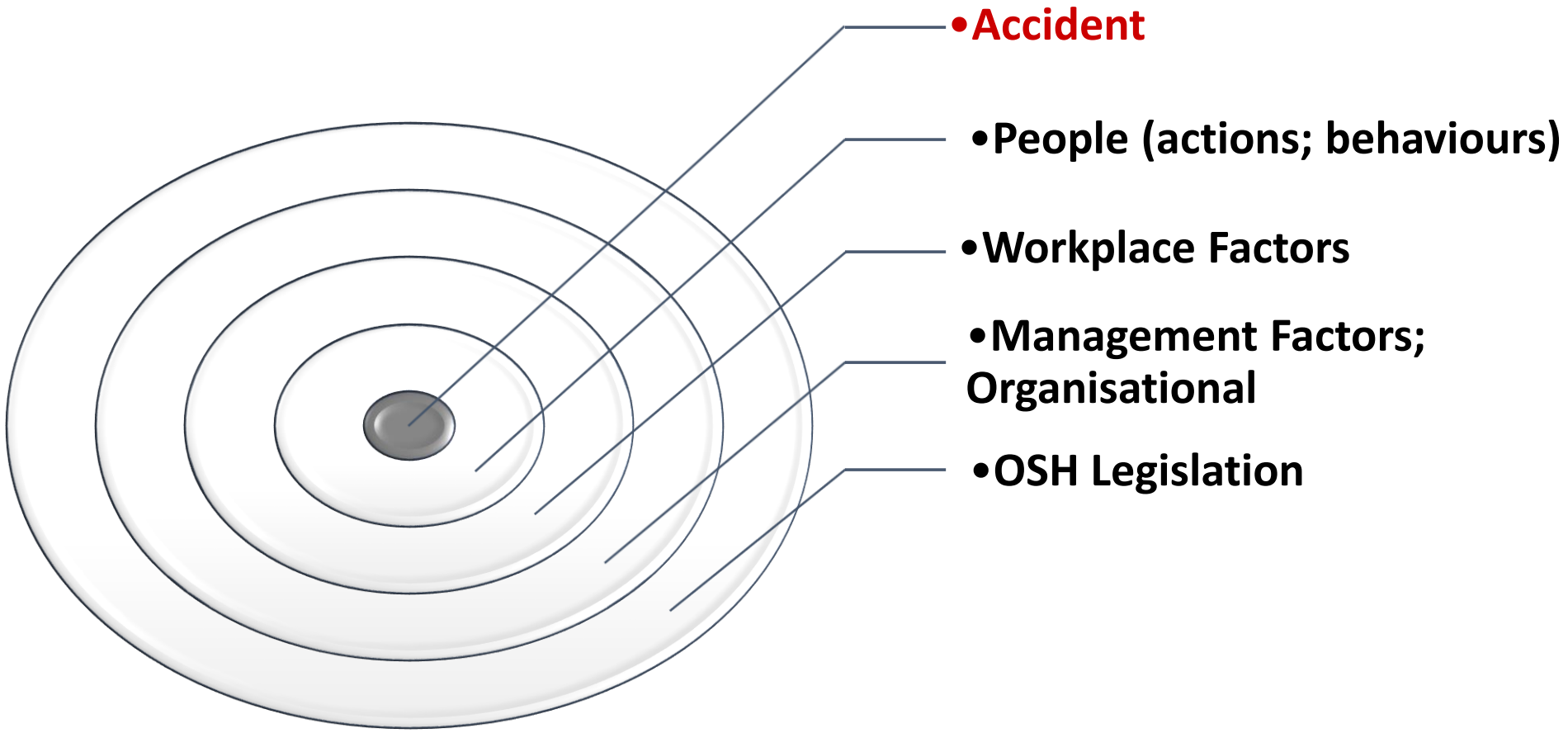


- A new “external layer” to account for OSH legal requirements
- In the spirit of the law, this is the first group of barriers

  (*immaterial barriers, which need to be well implemented)*

Part 2 – Investigation & Analysis (causes)

Search in 4 layers – the causes of the accident and also all underlying factors (latent) that facilitated its occurrence

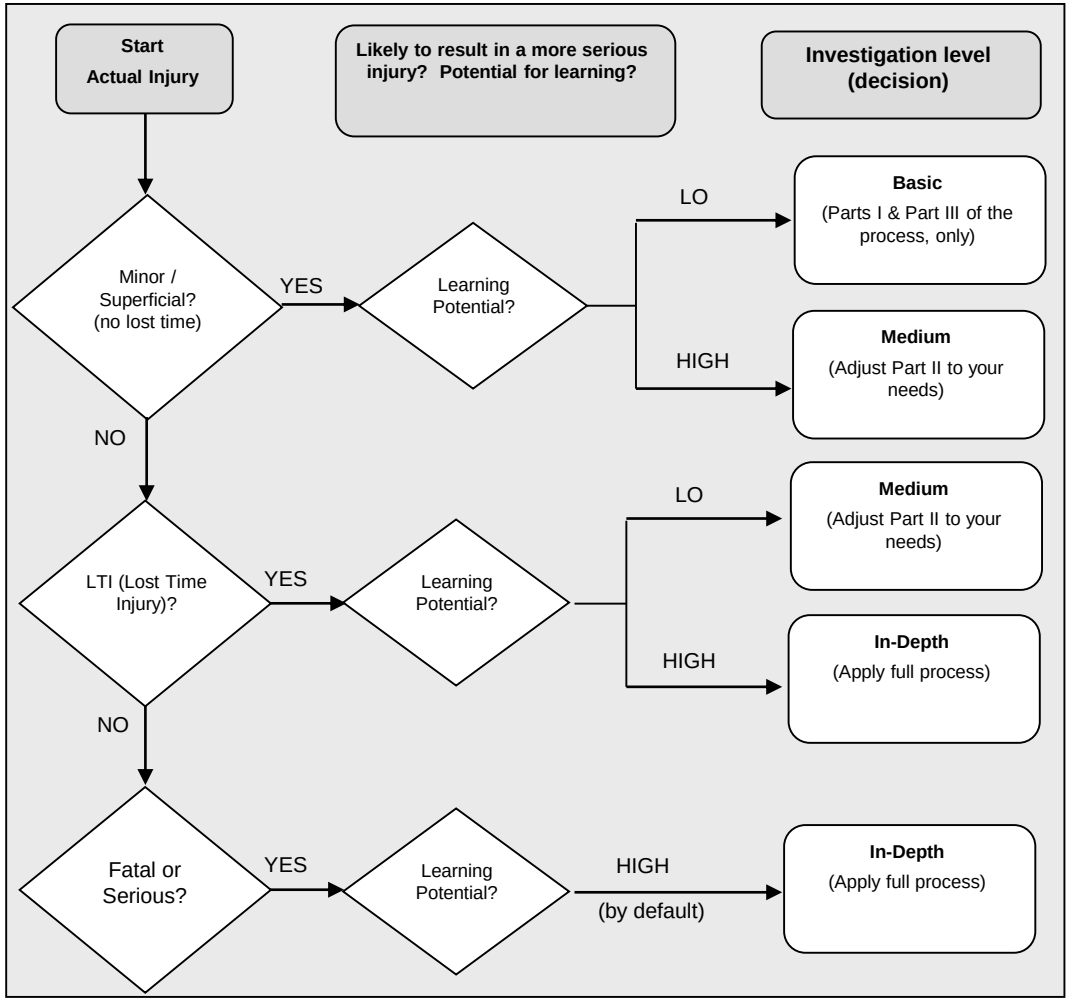


Part 2 – how much effort?

Basic

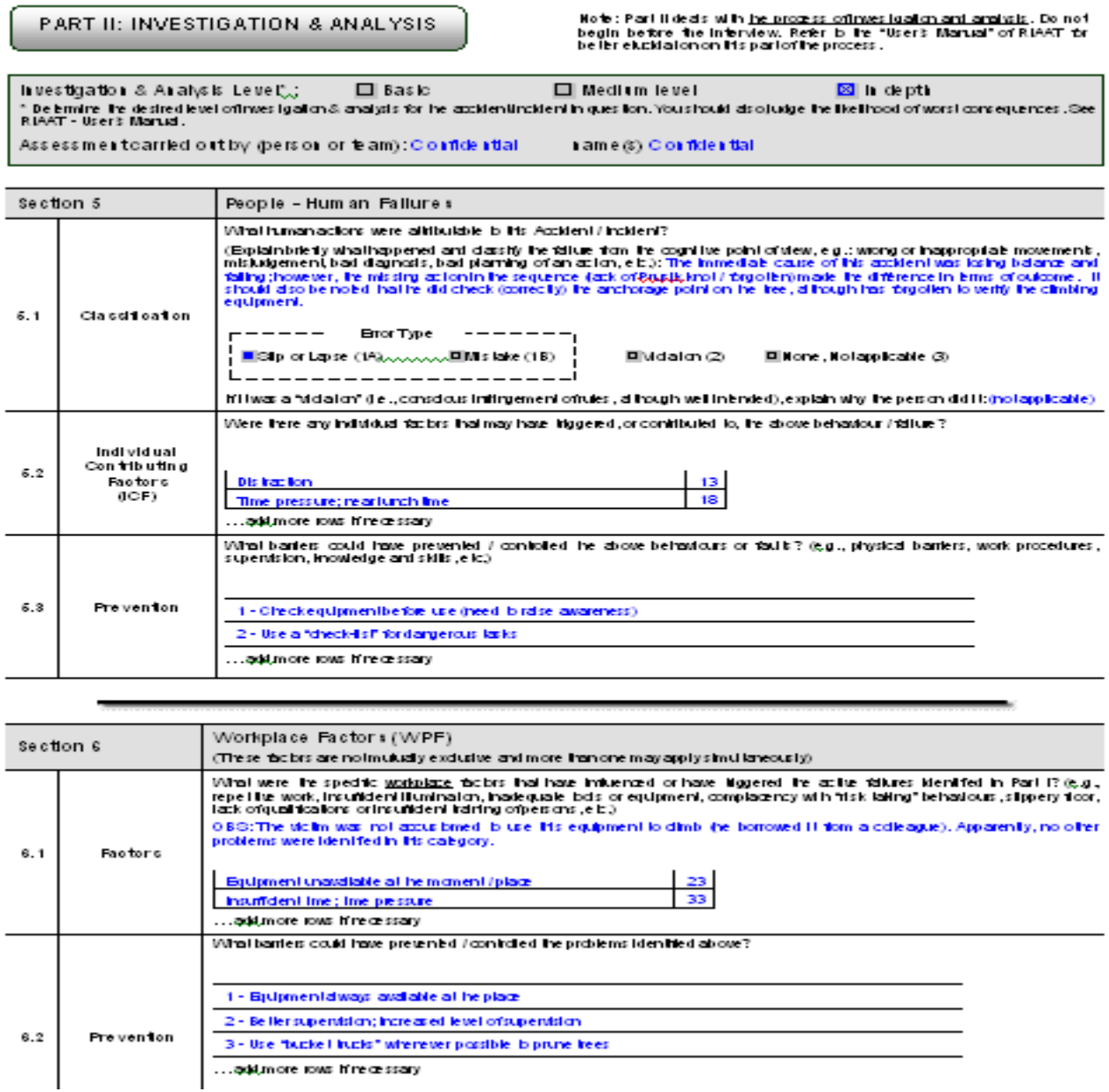
Medium

In-depth



Decision tree for deciding the level of investigation

Part 2 – Investigation & Analysis (causes)



PART II: INVESTIGATION & ANALYSIS

Note: Part II deals with the process of investigation and analysis. Do not begin before the interview. Refer to the "User's Manual" of RIAAT for better elucidation on this part of the process.

Investigation & Analysis Level: ☐ Basic ☐ Medium level ☒ In depth

* Determine the desired level of investigation & analysis for the accident/incident in question. You should also judge the likelihood of worst consequences. See RIAAT - User's Manual.

Assessment carried out by (person or team): Confidential name(s): Confidential

Section 5		People – Human Failures
5.1	Classification	What human actions were attributable to this Accident / Incident? (Explain briefly what happened and classify the failure from the cognitive point of view, e.g.: wrong or inappropriate movement, misjudgement, bad diagnosis, bad planning of an action, etc.): The immediate cause of this accident was losing balance and falling; however, the missing action in the sequence (lack of [illegible] / forgotten) made the difference in terms of outcome. It should also be noted that he did check (correctly) the anchorage point on the tree, although has forgotten to verify the climbing equipment. Error Type ☒ Slip or Lapse (1A) ☐ Mistake (1B) ☐ Violation (2) ☐ None, Not applicable (3) If it was a "violation" (i.e., conscious infringement of rules, although well intended), explain why the person did it: (not applicable)
5.2	Individual Contributing Factors (ICF)	Were there any individual factors that may have triggered, or contributed to, the above behaviour / failure? Distraction 13 Time pressure; near lunch time 18 ...add more rows if necessary
5.3	Prevention	What barriers could have prevented / controlled the above behaviours or fault? (e.g., physical barriers, work procedures, supervision, knowledge and skills, etc.) 1 - Check equipment before use (need to raise awareness) 2 - Use a "checklist" for dangerous tasks ...add more rows if necessary

Section 6		Workplace Factors (WPF) (These factors are not mutually exclusive and more than one may apply simultaneously)
6.1	Factors	What were the specific workplace factors that have influenced or have triggered the active failures identified in Part I? (e.g., repetitive work, insufficient illumination, inadequate tools or equipment, complacency with "risk taking" behaviour, slippery floor, lack of qualifications or insufficient training of persons, etc.) OBS: The victim was not accustomed to use this equipment to climb (he borrowed it from a colleague). Apparently, no other problems were identified in this category. Equipment unavailable at the moment / place 23 Insufficient time; time pressure 33 ...add more rows if necessary
6.2	Prevention	What barriers could have prevented / controlled the problems identified above? 1 - Equipment always available at the place 2 - Better supervision; increased level of supervision 3 - Use "tackle trucks" whenever possible to prune trees ...add more rows if necessary

The Manual provides classification lists for each category of factors

1

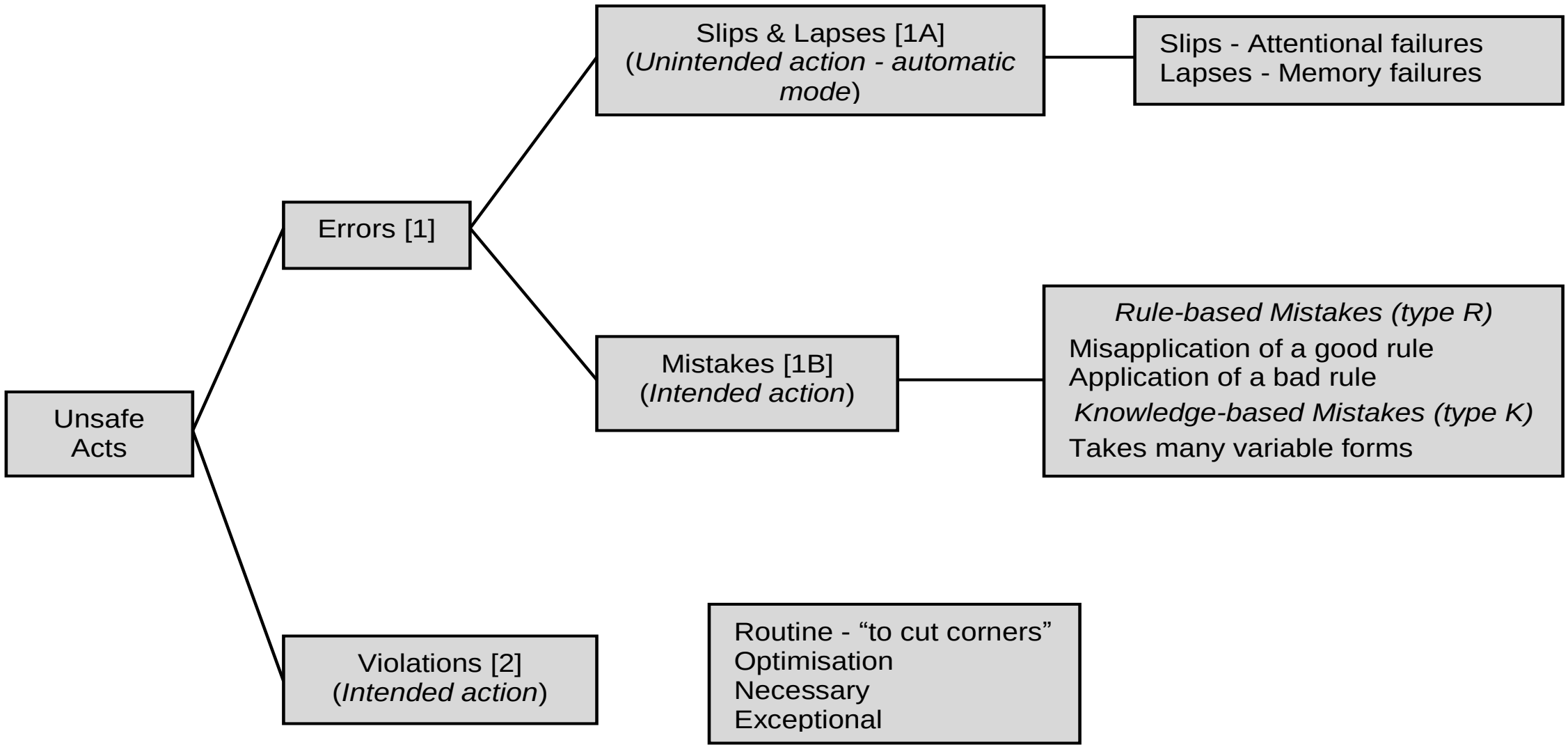
Analysis of Human Failures and Individual factors - **IND**

2

Workplace Factors - **WPF**

2 pages

Analysis of human failures (errors & violations)



Human Error Types/ taxonomy (adapted from Reason, 1990, p.207)

Reason classification for error types

Error Types

The error types can be classified into the following levels of “cognitive performance”:

Slips and Lapses – Unintended actions. Slips refer to attentional or perceptual failures in observable actions, while lapses are internal mental events, generally involving memory failures.

Rule-based mistakes (R type) – Intended actions. These errors are “mistakes” associated with behaviors that require application of rules or procedures. A typical question to make to characterize performance at this level is whether the procedure or rule exists.

Knowledge-based mistakes (K type) – These errors are “mistakes” at the level of individual knowledge; they occur when a worker faces new situations, for which he has no rules or applicable knowledge. These are linked, for instance, with difficult diagnosis.

Part 2 – (*continuation*)

Section 7		Organisational & Management Factors (OMF) (These factors are not mutually exclusive and more than one may apply simultaneously)
7.1	Factors	What organisational and management factors or conditions may have facilitated the previous workplace failures? (e.g., management of contractors, level of supervision, maintenance management, training policy, safety policy, etc.)

Purchasing policy (uniformity of equipment and tools)	15
Level of Supervision (less than adequate)	22
Identification of specific training requirements	42

...add more rows if necessary

7.2	Management Improvement and Control	What corrective actions are needed to improve the management of safety?

1 - Purchase identical / uniform equipment
2 - Create checklist for dangerous tasks
3 - Provide continuous training to workers (to be discussed with management)

...add more rows if necessary

Section 8	Legal Factors – H&S Legislation
Legal Issues	(Check if any of the failures identified in sections 6-7 constitutes a legal breach and/or if the applicable law is, by itself, more of a problem than a solution) ☐ Yes ☐ No If (Yes), cite the law or regulation applicable (Column 1) and describe what needs to be done for compliance (Column 2)

	1 - Law / Regulation	2 - Description
1	Decree 50/2005, of 25th February	Establishes the minimum safety requirements of work equipment; in particular it covers mobile equipment and devices for lifting loads. Defines rules on the use of work equipment. Establishes a mandatory check of work equipment at the beginning of its use, at regular intervals and when there are exceptional facts that could heavily affect its safety.
2	Law 59/2008, of 11th September - art. 87	Employers should provide adequate information and training for the prevention of accidents and illnesses at the workplace.

...add more rows if necessary

Section 9	Sign Off (Investigation & Analysis)
Signature of Investigator: Confidential	Date (year/month/day):
Signature of Reviewer / or Team Leader: Confidential	Date (year/month/day):

3

Management & Organisational Conditions – M&O

4

Legal OSH (*legislation*)

Part 3 – Plan of Action

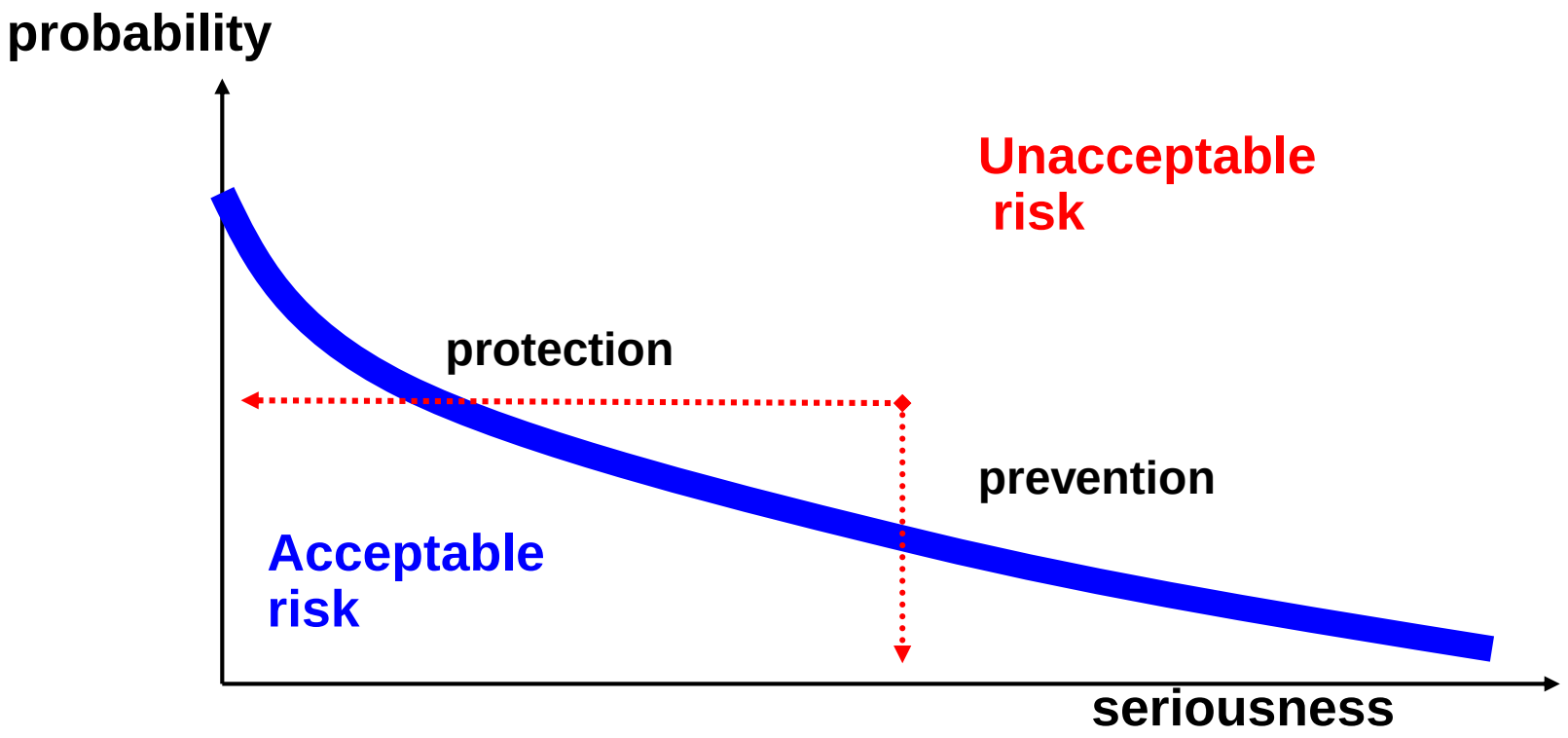
1 page
2 sections

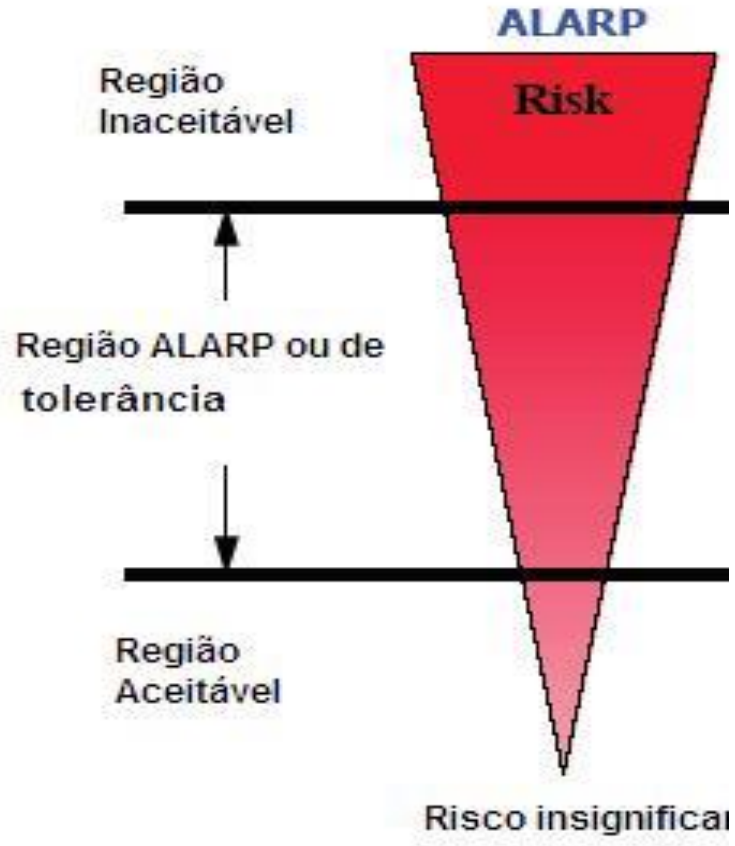
Aim

1) To ensure that all applicable **Risk Assessments** (RA) are complete and/or are reviewed in the light of this particular case

2) To establish an adequate (and sufficient) **Plan of Action**, based on "ALARP" – *As Low As Reasonably Practicable*)

The ALARP principle





Prevention and Protection measures should help to reduce risk to a level

"As Low As Reasonably Practicable"

Part 4 – Learning cycle

1 page
2 sections

Aim

1) To ensure that the important lessons are extracted and that knowledge is used. In this section, the RIAAT Form prompts the investigator to answer two key questions:
What was the lesson? Why? Who did learn?

2) To make sure that the important lessons are shared with targeted people. *Whom to share? How?*

5. Concluding Remarks

Accident Investigation & Analysis

Literature is plenty of ideas, new standards, new methods, new ways, etc.,

There is no excuse for not doing it, but methods are there to help, not to dictate rules

The effort is worth doing only if it means learning

Accident Investigation and Analysis

Thank you for your attention

Celeste Jacinto (mcj@fct.unl.pt)
Industrial Engineering, Universidade Nova de Lisboa

UNIVERSIDAD DE MÁLAGA

Thematic Seminar presented at
Universitad de Málaga
28 November 2016